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[Title of the Invention] Electrophoretic display device

[Claims]

[Claim 1] An electrophoretic display device comprising a dispersion containing electrophoretic particles confined between a pair of opposing electrode plates at least one of which is transparent, the distribution state of the electrophoretic particles in the dispersion being changed under a voltage for display control applied between the electrodes to change optical reflection characteristics and thus to obtain a predetermined display operation, wherein a number of microcapsules each including the dispersion confined therein are formed, the dispersion containing at least one type of electrophoretic particles dispersed in a colored dispersion medium whose optical characteristics are different from those of the electrophoretic particles, and the microcapsules are placed between the electrode plates.

[Claim 2] An electrophoretic display device according to claim 1, wherein volume resistivities of the dispersion and a film of the microcapsules are substantially equal to each other.

[Detailed Description of the Invention]

"Field of the Invention"

The present invention relates to a display device utilizing electrophoretic particles. More specifically, the present invention relates to an electrophoretic display device where a dispersion containing electrophoretic particles dispersed in a dispersion medium is confined in microcapsules, and such microcapsules are placed between electrode plates.

"Prior Art and Problems to be Solved"

The above type of electrophoretic display device using electrophoretic particles is constructed as follows. A dispersion containing electrophoretic particles dispersed in a liquid dispersion medium is confined between a pair of electrode plates disposed to face each other, at least one of which is transparent. The polarities of the electrode plates are controlled so that the electrophoretic particles in the dispersion medium can be drawn towards or moved away from the transparent electrode plate, thereby to allow desired characters, symbols, and diagrams to be displayed. As the liquid dispersion medium for the dispersion, alcohol solvents, various esters, aliphatic hydrocarbon, alicyclic hydrocarbon, aromatic hydrocarbon, hydrocarbon halide, and various other oils may be used individually or in an appropriate mixture thereof, with addition of an appropriate amount of a surfactant and the like. As the electrophoretic particles, titanium oxide, carbon black, Prussian blue, phthalocyanine green, and the like are generally known.

Figure 2 shows a conceptual sectional view of a main portion of such an electrophoretic display device.

The reference numerals 1 and 2 respectively denote transparent members such as glass plates and transparent electrodes formed in a predetermined pattern on one surface of the transparent members. A dispersion 10 containing electrophoretic particles is confined between the pair of transparent electrodes 2 disposed to face each other. In this regard, when the dispersion 10 is simply put in the space between the electrodes 2, the electrophoretic particles tend to aggregate with each other and attach to the electrodes so as to produce uneven display. In order to avoid this problem, a structure is known where a meshed or porous spacer 9 having a number of through holes 9A of an appropriate shape as shown in Figure 3 is disposed between the electrodes 2. This serves to divide the dispersion 10 into discontinuous portions, thereby stabilizing the display operation.

In such an electrophoretic display device having the porous spacer 9, after the porous spacer 9 is disposed between the transparent electrodes 2, the dispersion 10 is put in the respective through holes 9A of the porous spacer 9. It is, however, quite difficult to put the dispersion 10 in such a large number of through holes 9A uniformly. To overcome this problem, an alternative method may be considered where, after the porous spacer 9 is formed on one of the transparent electrodes 2, the dispersion 10 is dropped in or applied to the respective through holes 9A, and then the other transparent electrode 2 is mounted to confine the dispersion 10. This method has a problem that, since the dispersion medium normally used for the dispersion 10 tends to be easily volatized, the characteristics of the dispersion 10 change, and thus it is difficult to obtain reproducibility.

[Object and Constitution of the Invention]

The objects of the present invention are to solve the above-described problems associated with the dispersion confined between the transparent electrodes by adopting a technique of microcapsulating the dispersion in advance, not using the porous spacer or the like as described above, and to provide an electrophoretic display device which ensures the confinement of the dispersion and realizes good electrophoretic display operation including the display of desired colors.

In order to attain the above object, the electrophoretic display device according to the present invention includes a dispersion including electrophoretic particles confined between a pair of opposing electrode plates at least one of which is transparent, the distribution state of the electrophoretic particles in the dispersion being changed under a voltage for display control applied between the electrodes to change optical reflection characteristics and thus to obtain a predetermined display operation, wherein a number of microcapsules each including the dispersion confined therein are formed, the dispersion containing at least one type of electrophoretic particles dispersed in a colored dispersion medium whose optical characteristics are different from those of the electrophoretic particles, and the microcapsules are placed between the electrode plates. The volume resistivities of the dispersion and the film of the microcapsules are preferably substantially equal to each other.

"Examples"

The present invention will be described in more detail with reference to an example shown in Figure 1.

Referring to this figure, a number of microcapsules 3 are placed between transparent electrodes 2 which are formed on the opposing surfaces of a pair of transparent members 1 made of glass plates or the like. Each of the microcapsules 3 is formed in advance by a microcapsulation technique by confining therein a dispersion 5 containing electrophoretic particles 4 dispersed in a dispersion medium. As the electrophoretic particles 4 contained in the dispersion 5 to be confined in the microcapsules 3, various organic and inorganic pigments, dyes, metal powders, glass and resin micropowders, and the like, as well as well known colloidal particles, may be used appropriately. As the dispersion medium for the dispersion 5, water, alcohols, hydrocarbons, halogenated hydrocarbons, and the like, as well as natural and synthetic oils, may be used. To the dispersion 5, electrolytes, surfactants, charge control agents including particles of metal soap, resin, rubber, oil, varnish, compounds, and the like, as well as dispersion agents, lubricants, stabilizers, and the like, may be added, if required. Moreover, the following may be performed appropriately: the charge of the electrophoretic particles 4 may be made uniformly positive or negative; a means for enhancing the zeta potential may be employed; the dispersion may be made uniform and stable; and the adsorption of the electrophoretic particles 4 to the transparent electrodes 2, the viscosity of the dispersion medium, and the like may be adjusted.

The dispersion 5 with the above constitution is satisfactorily mixed by an appropriate means such as a ball mill, a sand mill, and a paint shaker. The dispersion 5 is then microcapsulated by an appropriate technique such as an

interfacial polymerization method, an insoluble reaction method, a phase separation method, and an interfacial precipitation method. At this time, the volume resistivities of the film of the microcapsules 3 and the dispersion 5 are preferably substantially equal to each other.

The thus-obtained microcapsules 3 are aligned on one of the transparent electrodes 2 by a technique such as a screen printing method, a roller printing method, and a spraying method. The resultant electrode with the microcapsules is then combined with the other transparent electrode 2, thereby to confine the microcapsules between the electrodes 2. The confinement of the dispersion 5 in the form of the microcapsules 3 between the electrodes 2 may be performed by another technique, where a required amount of the microcapsules 3 are injected into the space between the electrodes 2 via an appropriate hole.

It is preferable in practice to fill the gaps between the microcapsules 3 and the gaps between the electrodes 2 and the microcapsules 3 with a material 7, which is chemically stable against the microcapsules 3 and has a refractive index and a volume resistivity substantially equal to those of the microcapsules 3, as shown in Figure 1 by injecting the material via an injection hole 6. The reference numeral 8 in this figure denotes an end sealing member.

"Effect of the Invention"

As described above, the electrophoretic display device according to the present invention is characterized in that the dispersion is microcapsulated in advance and

the resultant microcapsules are placed between the electrodes for display control. With this arrangement, at least the following effect is obtained.

Since the composition of the microcapsulated dispersion is maintained uniformly, the conventional problems of the aggregation of electrophoretic particles and the attachment of the electrophoretic particles to the electrodes can be solved. Thus, uniform and stable display operation can be obtained.

Since the microcapsules are aligned between the electrodes for display control, the dispersion is prevented from being adversely effected by the assembling and the like, and the handling of the dispersion or the confinement of the dispersion can be markedly improved. Thus, the electrophoretic display device with good characteristics can be obtained.

In the advance microcapsulation, dispersions with different display colors for different types may be prepared, and microcapsules including the dispersions with different colors may be appropriately aligned so as to obtain desired color display. In this case, no walls or partitions are necessary.

[Brief Description of the Drawings]

Figure 1 is a conceptual sectional view of a main portion of the electrophoretic display device provided with microcapsules for confining a dispersion according to an example of the present invention.

Figure 2 is a conceptual sectional view of a main

portion of a conventional electrophoretic display device provided with a porous spacer.

Figure 3 is a partial perspective view illustrating a construction of the porous spacer.

1: transparent member
2: transparent electrode
3: microcapsule
4: electrophoretic particles
5: dispersion
9: porous spacer
10: dispersion